SANDAKANIA 16 (2005): 63–79

The forests of the Bukau–Api-Api area, Klias Peninsula

A botanical assessment and conservation perspective

Robert C. Ong, Reuben Nilus, George H. Petol, John B. Sugau & S.P. Lim

Forest Research Centre, Sepilok,
P.O. Box 1407, 90715 Sandakan,
Sabah, Malaysia

Summary. The Klias peninsula in Sabah, with some 130,000 ha land area, includes peat swamp forests, mangroves, nipah swamps, freshwater swamp forests, kerangas, and open marshes, making it a significant wetlands locality. A general survey conducted under the Sabah Biodiversity Conservation Project's Identification of Potential Protected Areas (IPPA) component revealed that good extents of these various vegetation types remain and should be conserved with careful management planning, even though threats such as fire, drainage of swampland, forest clearing, illegal encroachment, commercial logging and agricultural development have taken a toll on the natural landscapes of the region.

A botanical assessment of the Bukau–Api-Api area in the Klias Peninsula was carried out under the Identification of Potential Protected Areas (IPPA) component of the Sabah Biodiversity Conservation Project (SBCP). The Project aims to identify areas in Sabah that are worthy of protection due to their uniqueness and environmental and conservation value. The forests of Bukau–Api-Api River area in the Klias Peninsula was identified as one of such sites.

The objectives of the assessment were to:

1. provide a general assessment of the flora of the Bukau–Api-Api area, including the Kg. Hindian, Nabahan, and Klias Forest Reserves;
2. ascertain the quality of the natural vegetation and identify conservation measures that may be taken to enhance or maintain the quality of the vegetation;
3. identify likely threats to the forests in the area and the impacts they may have; and
4. identify the potential impacts of forest loss and drainage in adjacent lands on the forests within forest reserve land.

The study site: Klias Peninsula

The Klias Peninsula encompasses some 130,000 ha of largely flat coastal plains that support the most extensive wetland areas on the west coast of Sabah. Its natural vegetation is a complex of peat swamp forests, mangroves, nipah swamps, freshwater swamp forests, kerangas, open marshes, fig forests and secondary dryland forests.

Six forest reserves representing a total of about 31,500 ha are located on the peninsula, while alienated land and stateland make up the bulk of the area. The six forest reserves and their legislated classes under the Forest Enactment, 1968, are shown in Table 1.

Table 1. Forest Reserves on the Klias peninsula, Sabah.

Forest Reserve	Designation	Area
Binsuluk F.R.	Class I Protection	12,106 ha
Klias F.R.	Class I Protection	3,630 ha
Padas-Damit F.R.	Class IV Amenity	9,027 ha
Kg. Hindian F.R.	Class IV Amenity	580 ha
Nabahan F.R.	Class IV Amenity	356 ha
Menumbok F.R.	Class V Mangrove	5,710 ha
	Total	31,409 ha

The Klias, Nabahan, and Kg. Hindian Forest Reserves form a cluster around the Bukau–Api-Api River area. Located in the southern portion of the Klias Peninsula, this general area was the focus of the botanical assessment (Fig. 1).

Vegetation Types

The vegetation of the Bukau–Api-Api area can be generally described as wetland vegetation, with lowland peat swamp forest (PSF) accounting for the largest portion of the area. Anderson (1963) distinguished six PSF associations from Sarawak and Brunei where PSFs cover more extensive areas than in Sabah. However, for the purpose of this report, the vegetation is simply classified as mixed peat swamp forest, *Gymnostoma* swamp forest, mangrove, and riverine vegetation.

Peat swamps support a unique kind of vegetation different from that of dryland sites, and which are specially adapted to grow under water-logged conditions (Fig. 2). The lowland coastal PSFs of the tropics, like that found in the Klias area, have been described as *ombrogeneous*, meaning that the source of water for their formation is almost exclusively

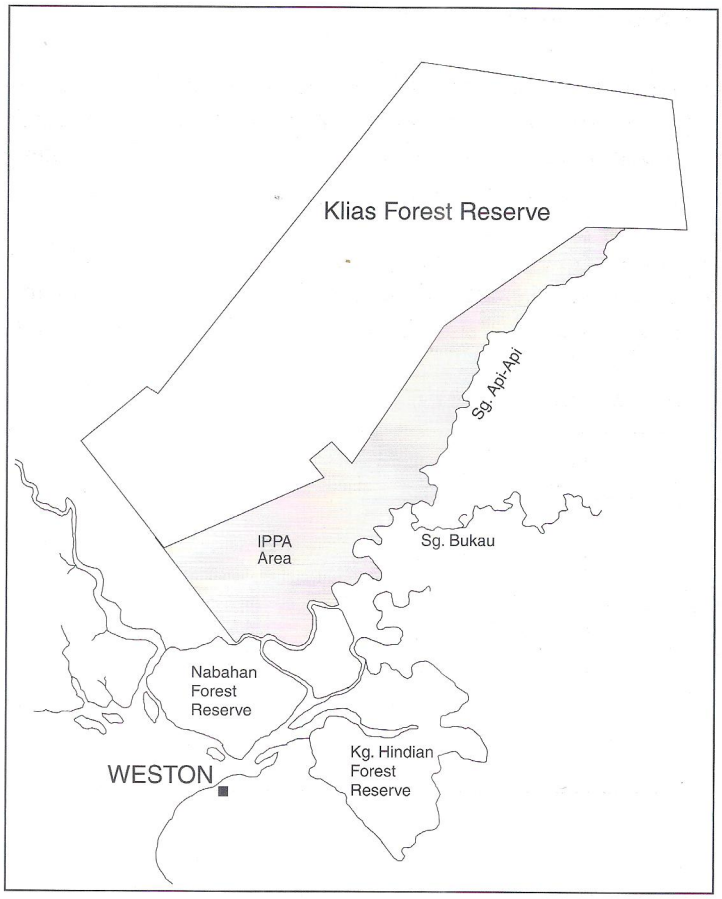

Fig. 1. The Bukau–Api-Api River area where the botanical assessment was carried out. This area includes the Klias, Nabahan, and Kg. Hindian Forest Reserves, and the IPPA area.

from rain water (Bruenig, 1990). They are rarely flooded by river water except for narrow strips along the river bank.

PSFs are generally less diverse than the dryland dipterocarp forest, but nevertheless still an important reservoir of biodiversity. Although they are lower in stature than the typical lowland mixed dipterocarp forest, they are an important source of valuable timbers.

Mixed peat swamp forest

The mixed PSF is characterized by the dominant association of several species, namely *Dryobalanops rappa* (kapur paya), *Shorea platycarpa* (seraya paya), *Dactylocladus stenostachys* (jongkong), and *Gonystylus bancanus* (ramin). Together, these species usually make up about 60–70 % of the standing basal area. Other common species include

Fig. 2. The stilt roots of this *Gymnostoma nobile* is an example of how trees adapt to the soggy and waterlogged conditions of the peat swamps. Nabahan Forest Reserve.

Calophyllum havilandii (bintangor), *Madhuca motleyana* (nyatoh ketiau), and *Stemonurus scorpioides* (katok).

Forest structure and floristic composition are not uniform within the mixed PSF. They may vary depending on peat depth and distance from adjacent dryland sites (Anderson, 1963; Rieley *et al.,* 1995). The canopy decreases in height and becomes more open in response to the increase in peat depth. Pandans (*Pandanaceae*) and sedges (*Cyperaceae*) are common ground cover and form impenetrable thickets where conditions are more open, thus allowing more light to reach the ground.

Gymnostoma swamp forest

Though they share overlapping elements, the *Gymnostoma* swamp forest is distinguished from the mixed PSF by the dominating presence of *Gymnostoma nobile* (sempilau laut), which is absent in the latter. Other commonly associated trees of the main canopy are *Palaquium rostratum* (nyatoh sidang), *Mezzettia havilandii*, *Alstonia spatulata* (pulai paya), and *Lophopetalum multinervium* (perupok). Canopy trees found here are large enough to be

of timber value. The widely planted ornamental palm, *Cyrtostachys renda* (Sealing wax palm), is widespread in this habitat.

Mangroves

Mangrove vegetation occurs up to the limit of tidal influence along coastal and estuarine delta areas. This ecosystem is not known for its plant diversity and is poorer overall than the PSFs in this respect. It is known for its floristic uniformity, showing little regional differences within South Asia. The *Rhizophoraceae* is the most dominant plant family found in the mangroves. Mangrove species usually occur gregariously, often in uniform or pure stands that in turn form natural vegetation zones. This led Fox (1972) to use species dominance for describing the various vegetation zones within this brackish ecosystem, such as *Avicennia alba*, *Bruguiera gymnorrhiza*, *Nypa fruticans*, *Rhizophora apiculata*, *R. mucronata*, and transitional forest.

Riverine forest

As the term suggests, this type of vegetation is found in narrow strips along the riverbanks where seasonal inundation occurs. Some of the common species noted along the Bukau–Api-Api river were *Dillenia excelsa*, *Dracontomelum dao*, *Flacourtia rukam*, *Mallotus muticus*, and *Vitex pubescens*.

Assessment methods

The different vegetation types were preliminarily identified and mapped with the aid of aerial photographs of the scale 1:25,000, which were taken in July 1995. An aerial survey by helicopter was carried out to get a better impression of the overall area, as well as to verify the interpretation of vegetation for those areas difficult to access. The aerial survey also allowed for the mapping of the area affected by the fire of 1998.

Field surveys were conducted over a one-week period at the beginning of May, 1998. General plant collecting and surveys were carried out at nine locations representing the different vegetation types found (Sites 1 & 2 along the SW margin of the Kg. Hindian Forest Reserve: Mangrove and mixed species Peat Swamp Forest; Site 3 at the NE part of Nabahan Forest Reserve, *Gymnostoma* swamp forest; Site 4 at the S portion of the IPPA area just north of the Api-Api river, mixed species Peat Swamp Forest; Sites 5 & 6 between the Api-Api river and the SE boundary of Klias Forest Reserve, mixed species Peat Swamp Forest of various conditions; Site 7 beside the Api-Api river at the E extreme of Klias Forest Reserve, Riverine Forest; Site 8 at the NE boundary of Klias Forest Reserve just SW of Site 7, mixed species Peat Swamp Forest; Site 9 at the NW boundary of Klias Forest Reserve, mixed species Peat Swamp Forest). At each location, observations were made of species frequency and dominance. Plants of special interest (e.g., species of economic value, or that were rare or localized) were also noted.

The Klias Forest Reserve

The Klias Forest Reserve is entirely mixed PSF. Prior to its gazettement as Class I Protection forest in 1984, it was a Class II Commercial Forest Reserve. Despite having been logged in the past, the forest within the reserve is generally intact and capable of regenerating naturally.

The Klias FR is very similar to the Binsuluk FR in terms of species composition, i.e., both areas are typified by the dominance of *Dryobalanops rappa, Dactylocladus stenostachys, Shorea platycarpa*, and *Gonystylus bancanus*. Kapur paya (*D. rappa*) appears to be one of the most dominant constituents of the upper canopy (Fig. 3). However, it could not be ascertained whether its current social status reflected the original structure of the forest. This is because past logging operations may have removed only commercial species, like ramin and jongkong, during a time when kapur paya was either not highly marketable or difficult to transport (the kapur logs sink in water). In the drier areas, the presence of *Shorea smithiana* (seraya timbau) was noted.

Going into greater detail, the mixed PSF of the Klias FR could be further stratified into three categories according to crown size and density. The cursory nature of the field assessment

Fig. 3. Mixed peat swamp forest of the Klias Forest Reserve. Trees that seem to dominate the upper canopy are *Dryobalanops rappa* (kapur paya, distinct in the field by their brownish-green crowns). *D. rappa* is endemic to Borneo.

did not allow for the detection of any differences in floristic composition between these strata. The dominant species associations, however, seem somewhat similar.

About 7% of the reserve was affected by fire in March 1998. There are also several clearings within the Klias FR where forest once stood and whose origins are unknown (Fig. 4).

The Kampung Hindian Forest Reserve

The Kg. Hindian FR is legally classified as an Amenity Forest Reserve. By virtue of this designation, it is mainly intended for recreational purposes, and is protected from commercial logging and other forms of human disturbance. It is easily accessible by road. In terms of vegetation, it is the most diverse forest reserve in the Bukau–Api-Api River area, comprising mixed PSF, *Gymnostoma* swamp forest, and almost the entire range of mangrove vegetation zones.

The mixed PSF which occurs to a small extent in the southern part of the reserve has been highly disturbed by what seems like small-scale selective felling over many years. The

Fig. 4. A clearing at the northeastern portion of the Klias Forest Reserve where peat swamp forest once stood.

presence of scattered large trees capable of producing seed for regeneration, as well as the patchy occurrence of pole-size trees of climax forest species, present opportunities for silviculture. With appropriate silvicultural measures, the mixed PSF in the Kg. Hindian FR can recover. Some of the species noted here were *Dactylocladus stenostachys, Calophyllum havilandii,* and *Madhuca motleyana.*

The relatively small patch of *Gymnostoma* swamp forest in Kg. Hindian is still very much intact and relatively undisturbed (Fig. 5). Here, the sealing wax palm (*Cyrtostachys renda*) grows abundantly.

Much of the mangrove vegetation is *Nypa fruticans* (nipah), associated with *Heritiera littoralis* (dungun) in certain places, while progressively further from the river *Cerbera odollam* and *Ficus benjamina* become more frequent.

Agricultural cultivation has encroached into the FR, especially in the north-eastern part of the reserve. There also appear to be private land titles that seem to overlap onto forest reserve land at the eastern side.

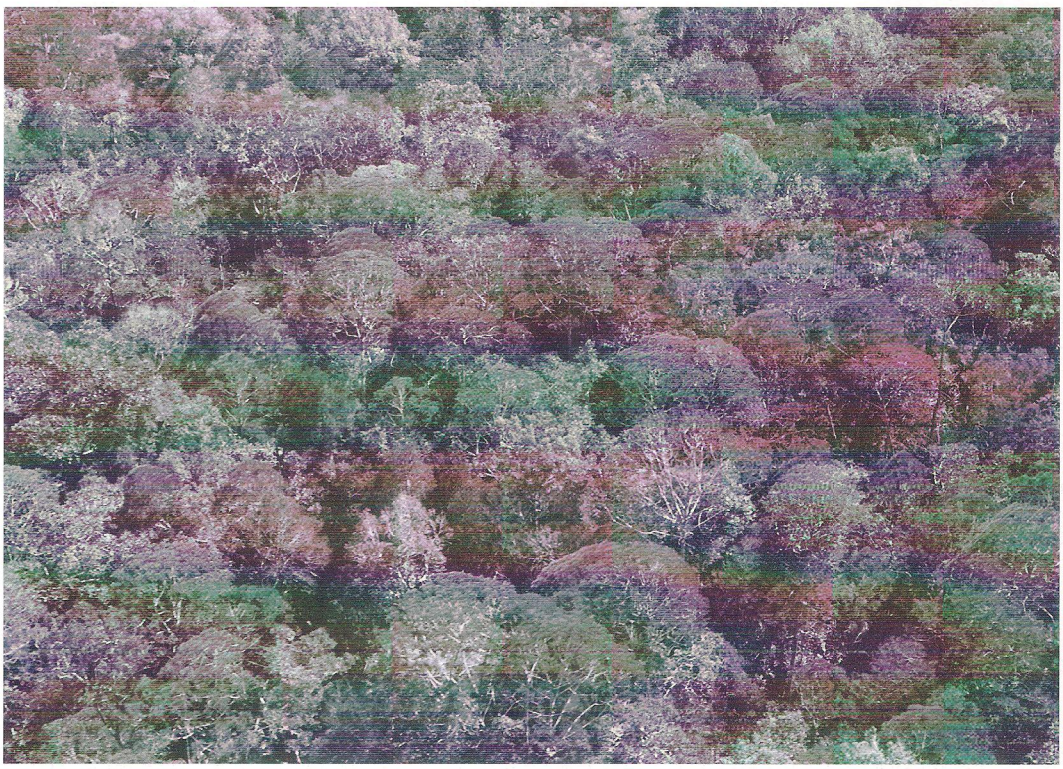

Fig. 5. *Gymnostoma nobile* swamp forest in the Kg. Hindian Forest Reserve. *G. nobile* (sempilau laut), a commonly planted ornamental tree, is easily recognized here as a dominant canopy tree by its fine-textured foliage.

The Nabahan Forest Reserve

The Nabahan Forest Reserve is also classified as Amenity FR. Access is by boat from Weston. The vegetation of the Nabahan FR comprises largely mangroves and *Gymnostoma* swamp forest. A fire in March 1998 burned about half of the *Gymnostoma* swamp forest while the remaining portion is still in good condition (Fig. 6).

Traces of recent small-scale illegal felling were detected during the field survey. The cause of the fire in the reserve is likely linked to the illegal operation.

The IPPA Area

The IPPA Area is so referred to because it was identified by the IPPA component of the SBCP for evaluation of its conservation value. The particular area being referred to is generally sandwiched between the Klias FR and the Bukau and Api-Api rivers (Fig. 1). The IPPA area is largely stateland that was currently under land application, while a part of it was a proposed Kampung Reserve. The vegetation is a mixture of all the vegetation types described earlier.

There is still about 400–450 ha of mixed PSF still in good condition in the IPPA area. During the field survey it was noted that a logging operation was in progress in the mixed

Fig. 6. More than half of the *Gymnostoma* swamp forest in the Nabahan Forest Reserve burned in March 1998. The fishing town of Weston can be seen in the background.

PSF. Nipah-dungun mangrove occupies much of the estuarine area. The remaining part of the IPPA area is young secondary vegetation, where presumably PSFs once stood, and a small extent of riverine forests.

Conservation status of mangroves and peat swamp forests

Mangrove swamps occur along a considerable length of Sabah's coastline, especially on the east coast where they are more extensive. Mangroves are resilient to some disturbance and natural regeneration does not normally present a problem. Due to the constantly wet conditions, fire risk is of no significance. And although they serve important ecological and environmental functions, mangroves are not considered threatened ecosystems in Sabah. For this reason, the rest of this report will focus mainly on the PSFs.

The conservation of PSFs in Sabah is a cause for great concern. PSFs once covered an estimated area of 100,000 ha state-wide, less than 2 % of the Sabah's land mass. Since their original coverage was never really extensive in Sabah, the PSFs as a distinctive vegetation type were always vulnerable where their conservation was concerned. At the individual species level, PSF species are therefore predisposed to an even greater threat considering that many species only grow in the peat swamps and nowhere else. This is further compounded by the floristic variation found between one area or region and another. For instance, the east coast PSFs are very different from the west coast PSFs with respect to species composition. The underlying causes for this variation are still poorly understood.

The Klias Peninsula formerly supported the largest extent of PSFs, some 60,000 ha in total. Virtually all the remaining mixed PSFs are found within the Binsuluk and Klias FRs, while some are found within the IPPA area. Unfortunately, recent fires which persisted during the *El Niño*-associated drought of 1998 have effectively destroyed more than half of the Binsuluk FR. Today, it is estimated that not more than 10,000 ha of the Klias PSFs remain intact.

The mixed PSFs of the Klias peninsula, as described earlier, only occur on the west coast of Sabah. The PSFs on the east coast are very different floristically in that perupok (*Lophopetalum multinervium*) is the single most dominant species (Nilus & Ong, 2001). Jongkong, ramin, kapur paya, and seraya paya which are common in the Klias mixed PSFs have never been recorded on the east coast. Coastal areas around Kimanis carried limited stands of mixed PSF at one time. This form of PSF also occurs to a very limited extent in the Marintaman-Mengalong FR, until recent forest fires destroyed the stand.

The *Gymnostoma* swamp forest which is found in the Nabahan FR also occurs in a small stand within the Kg. Hindian FR. However, fires sparked during the drought of 1998 destroyed more than half of the *Gymnostoma* swamp forest in the Nabahan FR. The only other area known to carry this form of PSF is the Sianggau FR close to Weston. A large part the PSF in Sianggau FR was also affected by fire during the same period. There are,

however, some small areas just outside the Sianggau reserve which support *Gymnostoma* swamps and kerangas forest. It would not be presumptive to say that less than 150 ha of the *Gymnostoma* swamp forest in Sabah remain in good condition or undisturbed.

Threats to conservation and their potential impacts

The socio-economic, ecological, and environmental importance of PSFs is well documented (Prentice & Parish, 1990; Rieley et al., 1995). However, human activities continue to threatened the ecological integrity of the PSFs and, hence, the environmental functions they provide. The major threats to the forests of the Bukau–Api-Api area are discussed below.

Fire

Fire poses a significant threat to the conservation of PSF in the Bukau–Api-Api area, and is expected to remain a serious threat as long as preventive measures are not taken. Forest clearing and burning for cultivation in surrounding areas during extended drought periods is likely to be the major cause of fires. Destruction of parts of the Klias and Nabahan FRs and a large part of the Binsuluk FR by the fires of 1998 bear testimony to the impact of fire (Fig. 7). It is difficult to predict how the burnt areas will recover.

Drainage

Trees growing in peat swamps are sensitive to changes in the mean water table level. Therefore, drainage of water from peat swamps may have damaging effects on the ecology and hydrology of PSFs. Drainage causes the water table level to drop. This could ultimately result in changes to the floristic composition of the forest, with plants that are more suited to the drier conditions succeeding those of the original wetter conditions. The drier conditions also lend themselves to greater fire risks.

Drainage is usually the result of canals being dug to drain water from adjacent land for agricultural development or for transportation of logs by floating them along the extraction canals. A network of canals is found just outside the northern boundary of the Klias FR. This would likely have affected the overall mean water table level of the peat swamp basin. How significant this change may be would be a subject of further investigation. The consequent impact of this change on the quality of the PSF, namely the forest within the Klias FR, is difficult to predict, and would require long-term research and observation. But one can expect a negative influence on the ecosystem integrity of the PSF. If the canals are close-ended, e.g., they do not drain out to a river, then the negative effects may be mitigated.

Another serious consequence of excessive drainage is *peat subsidence*—peat being the very medium that supports the existence of PSFs. According to Salmah (1997), land uses that involve the extensive drainage of peat soils cause peat to wash away or subside and

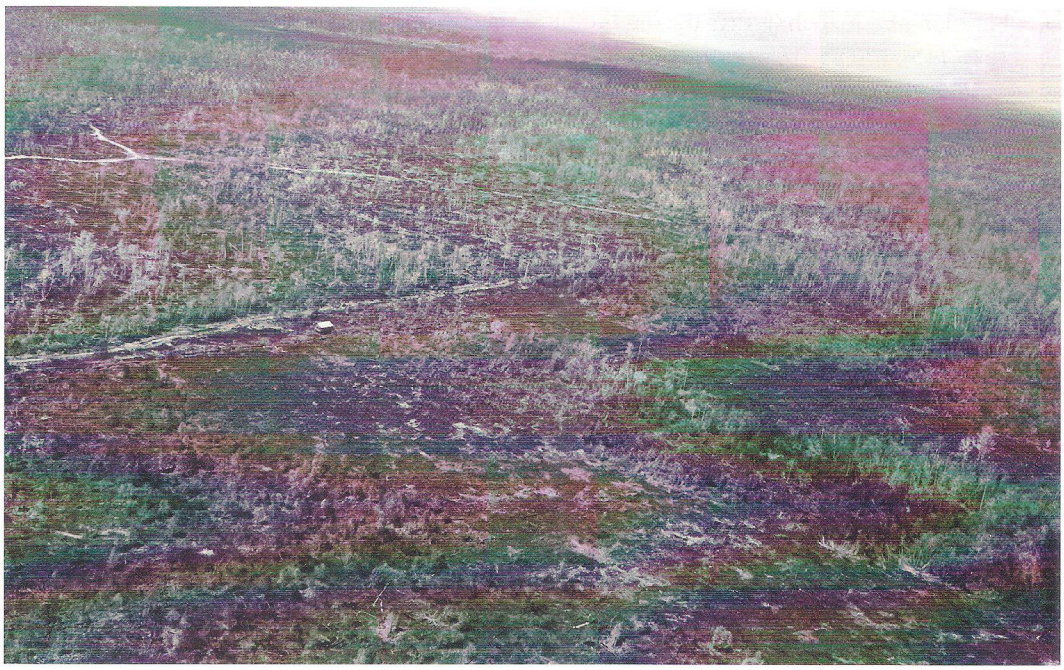

Fig. 7. Fires burned extensive areas in the Klias Peninsula in February-March 1998. This burnt area just outside the far eastern boundary of the Klias Forest Reserve once supported peat swamp forest. Today, fires present one of the greatest threats to the conservation of peat swamps.

'oxidise', until ultimately the peat deposit is completely depleted. Once depleted, the subsoil of peat areas will be exposed. The underlying subsoils are usually sandy podsolic soils or acidic sulphate clays, both types seriously nutrient-deficient and not likely to support agriculture.

Forest clearance

Forest clearance in surrounding peat swamp areas can also be expected to result in the general lowering of the mean water table level, and hence also peat subsidence. The open conditions created by the removal of the protective forest cover would have a drying-out effect on the peat swamps because of the associated increase in the rate of evaporation from the swamps. Although some remain in the IPPA area, much of the PSFs outside the Klias FR have already been cleared or destroyed by fire. Due to the absence of long-term monitoring plots in the Klias FR, it cannot be determined how these clearings have affected or will affect forest dynamics.

Illegal felling and encroachment

Illegal felling is always a threat to the conservation of any forest ecosystem, especially one whose conservation status is very vulnerable. Small-scale illegal felling was detected in the

Kg. Hindian and Nabahan FRs during the field survey. In the Kg. Hindian FR, illegal felling was found to occur at the fringe of the FR, where the boundary is directly adjacent to private land holdings, and where access is easy. Circumstantial evidence suggests that owners or occupiers of land adjacent to FRs are likely to have had a hand in these illegal fellings. Logs are sawn in the forest and removed as planks or sawn timber. It was also noted that logs of certain species (e.g., *Calophyllum havilandii* or bintangor) were felled to make dug-out canoes. Considering that the PSF is such an endangered ecosystem in Sabah, any loss of large fruit-bearing trees is a threat to biodiverstiy conservation.

Illegal agricultural encroachment by private land owners could be a serious threat if it is allowed to extend further. This problem may have arisen due partly to the absence of clear boundary demarcation of forest reserves.

Commercial logging

Ever since their gazettement as Protection and Amenity forests in 1984, commercial logging has been prohibited in the three FRs of the Bukau–Api-Api river area. Therefore, as a threat to conservation within these forest reserves, commercial logging is not an issue. However, commercial logging on stateland, namely in the IPPA area, remains a significant threat to conservation.

Agricultural conversion

Although the Klias Forest Reserve itself may not be converted for agricultural use, the conversion of surrounding areas for large-scale agricultural development (e.g., oil palm plantations), which invariably require extensive drainage, would be threatening to the integrity of the peat swamp ecosystem.

Generally, peat swamps are unsuitable for traditional agriculture. A few selected crops may be grown on peat, but the associated cost of developing agriculture on peat areas is high. This is especially true when the peat layer is very deep. In the Klias Peninsula, it can reach a depth of 15 m. Peat soils possess poor physical and nutritional properties that require amelioration for the successful cultivation of tree crops like oil palm. The soft conditions associated with the low bulk density, causes palms to lodge and lean as they mature, and is also a constraint to the movement of workers and their machinery (Fig. 8).

Conclusion and recommendations

The Bukau–Api-Api river area supports a complex of unique wetland habitats, some of which are no longer found elsewhere in Sabah outside the Klias Peninsula. Of these, the PSFs are the most highly threatened. The destruction of wetlands conflicts with the new National Wetland Policy which recognizes the importance of wetlands for environmental

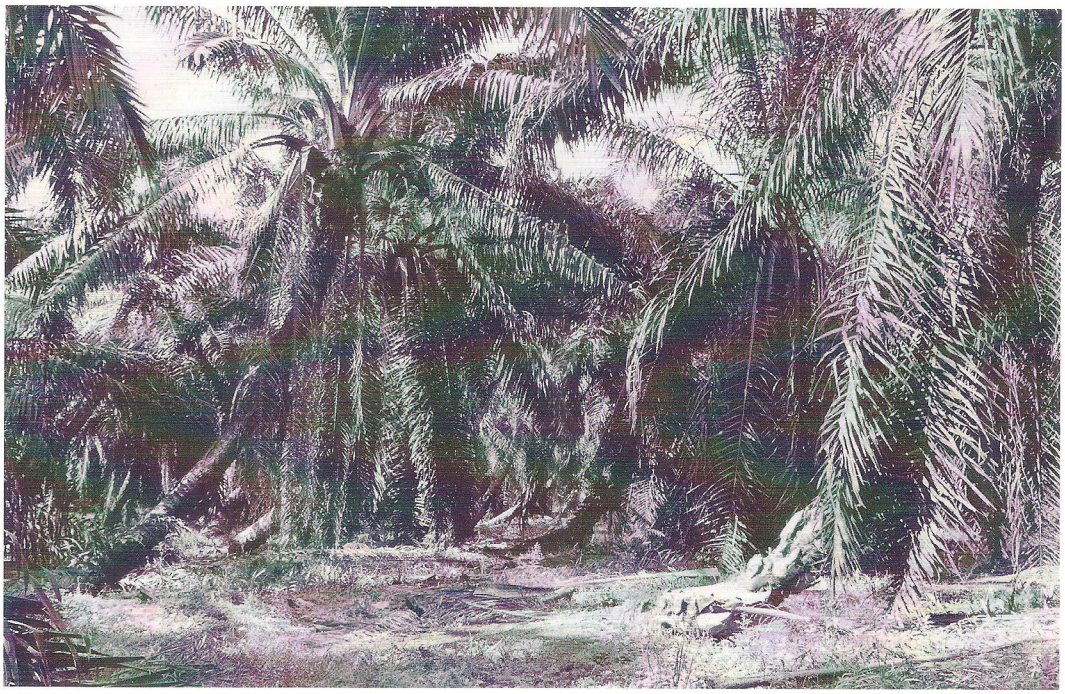

Fig. 8. Oil palms grown on deep peat tend to lean and fall over as they mature. This phenomenon was observed at the Mawao Estate, Klias Peninsula.

preservation. Due to the many ecological uncertainties, it is always advisable to take a conservative approach in development planning involving peat swamps. Various measures will need to be taken to protect the ecological integrity of wetlands in the Bukau–Api-Api area.

Research

Despite their known socio-economic and environmental importance, there are much less detailed studies carried out in the PSFs compared to the dryland forests. Consequently, much less is known about the flora and ecology of the PSFs. This is due largely to the difficult working conditions in the peat swamps and poor accessibility. However, the increasing threat to the conservation of PSFs in Sabah has underscored the urgent need for research which would directly contribute to their conservation and sustainable use.

Phenology. The flowering and fruiting patterns of selected species would be very useful to understand, with the ultimate aim of collecting seed for rehabilitation purposes. This should also lead to studies on seed biology and nursery techniques.

Regeneration and rehabilitation ecology. Vast areas of PSFs have been degraded to various degrees of severity, with very little possibility for regeneration without human assistance.

Studies aimed at devising viable techniques to rehabilitate these degraded areas, such as identifying suitable species and trial plantings of these selected species would be necessary. The rehabilitation of degraded PSFs has hardly been attempted in Malaysia, although some initiatives have begun in Peninsular Malaysia very recently. Where the effects of fire do not appear so severe, it would be worthwhile to monitor how the burnt forest recovers and regenerates naturally, and also to study if conditions are still amenable to artificial regeneration.

Forest dynamics. Long-term observations to study forest regeneration and to monitor changes in the structure and quality of the PSFs would be extremely important. Such studies will entail the establishment of permanent research plots. This would ultimately enable us to detect any decline or improvement in the health of the forest as a result of forest loss and land development activities in the surrounding areas.

Floristic diversity and vegetation quality assessment. A comprehensive assessment and documentation of the flora of PSFs in Sabah has never been undertaken. A comprehensive assessment will also be required to locate and provide accurate information on the remaining extent of PSFs in Sabah, both within statelands and forest reserves. Such information would be fundamental in the formulation of a conservation strategy for this threatened ecosystem. More detailed information will also allow comparisons to be made with the PSFs of Brunei and Sarawak, where they have been more well-studied.

Peat swamp forests may prove to be an important source of non-timber forest products with potential for commercialization, e.g., medicinal plants. These possibilities have hardly been explored. If this unique ecosystem is destroyed, all opportunities for any discovery are lost forever.

Fire protection

The destructive consequences of recent fires have now made it evident that fire is a major threat to the conservation of PSFs. Fire protection plans should be put in place, with special attention given to create awareness among those living in close proximity to critical PSF areas.

Forest Reserve boundary demarcation

The boundaries of forest reserves should be demarcated clearly, especially where they share a common border with private land holdings. This would enable better control and monitoring of adjacent activities, and hopefully prevent further encroachment. Sign boards indicating restricted area status should be prominently displayed at strategic places. Several local individuals interviewed during the field work were found to be oblivious of the existence and location of nearby FRs. The problem of overlapping boundaries with private lands will also need to be resolved without delay.

Expansion of the Klias FR

It is highly recommended that the eastern boundary of the Klias FR be extended to include the IPPA area. The extended FR boundary should be the existing boundary of stateland / alienated land just east of the Api-Api River. This will ensure that, not only is the extensive PSF on the western side of this river protected, but also that a strip of natural forest is maintained along the western river bank. And by this, the river forms a natural barrier against encroachment, and makes boundary surveillance easier.

The IPPA area is largely under land application, partly stateland, while a portion is proposed Kampung Reserve land. Experience has shown that serious encroachment problems arise when communities are established directly adjacent to forest reserves, and where a clear and easily accessible boundary (e.g., roads and rivers) is not present to facilitate control and monitoring. The IPPA area is presently uninhabited for two main reasons: 1) access is difficult because of the barrier formed by the Bukau and Api-Api rivers, and 2) the area is mainly wetland and flood-prone.

This proposed expansion will protect a portion of the already-scarce PSFs that is presently outside the reserve, and therefore strengthen the ecosystem's integrity. Not much land that is suitable for development will be forgone by this expansion because a considerable part of the area comprises nipah swamps and mangrove, while the peat swamp area is not particularly suitable for human settlement.

Forest Management Plan

Eventually, it would be highly desirable that a plan be drawn up in order to regulate activities and provide direction for the management of the Bukau–Api-Api area which is compatible with its conservation objectives. This area, encompassing the three FRs and the present IPPA area, should be managed as a single management unit. A fully functional management plan will also ensure the systematic documentation and record-keeping of activities and resource information. Such empirical information is of great importance in the process of management decision-making.

ACKNOWLEDGEMENTS

The Identification of Potential Protected Areas (IPPA) component of the Sabah Biodiversity Conservation Project (SBCP) was implemented through the then State Ministry of Culture, Environment, and Tourism with funding and support from the Danish Co-operation for Environment and Development (DANCED), World Wide Fund for Nature Malaysia (WWFM), and the Sabah Forestry Department. During fieldwork and in the preparation of the report, the assistance and support of the following persons are acknowledged: Mr Sam

Mannan (Director, Forestry Department), Dr Junaidi Payne (WWF Malaysia), Mr George Angampun (District Forest Officer, Beaufort), Rosila Anthony and Dimeh Koyopo (Forestry Department Headquarters, Sandakan). The field assessment team also included Leopold Madani, Dewol Sundaling, Ahmad Ibrahim, Harun Majed, Ahmad Sappan, Postar Miun (Forest Research Centre, Sandakan) and Shahril Kamarulzaman (WWF Malaysia).

REFERENCES

Anderson, J.A.R. (1963) The Flora of the peatswamp forests of Sarawak and Brunei, including a catalogue of all recorded species. *Gardens' Bulletin, Singapore* 20: 131–228.

Bruenig, E.F. (1990) Oligotrophic Forested Wetlands in Borneo. In: A.E. Lugo, M. Brinson & S. Brown (eds.), *Ecosystems of the World 15*. Elsevier Publishing. 527 p.

Fox, J.E.D. (1972) *The Natural Vegetation of Sabah and Natural Regeneration of the Dipterocarp Forest.* Unpublished PhD Thesis, University of Wales, 350 p.

Nilus, R. & R.C. Ong (2001) Floristic Composition of the Perupok Swamp Forest of the Sugut Forest Reserve, Sabah. In: K.M. Wong, S.S. Lee & G. Saari (eds.), *Species, Landscapes and Islands, Perspectives in Tropical Botany*. Malaysian Nature Society, Kuala Lumpur, pp 95–101.

Prentice, C. & D. Parish (1990) Conservation of Peat Swamp Forests: A Forgotten Ecosystem. In: S.K. Yap & S.W. Lee (eds.), *Proceedings of the International Conference on Tropical Biodiversity: In Harmony With Nature.* Malaysian Nature Society, Kuala Lumpur, pp 128–144.

Rieley, J.O., S. Page & G. Sieffermann (1995) Tropical Peat Swamp Forests of Southeast Asia: Ecology and Environmental Importance. *Malaysian Journal of Tropical Geography* 26(2): 131–141.

Salmah, Z. (1997) Hydrology and Infrastructure Requirements in Peat Areas. In: *Proceedings of the GEF Inception Workshop on Conservation and Sustainable Use of Peat Swamp Forests in Malaysia*, 24–25 July, 1997, Kuala Lumpur, Malaysia, pp 37–43.